DYNA3D Enhancement and Support

For more information contact **Jerry I. Lin**
(925) 423-0907, lin5@llnl.gov

The explicit finite-element code DYNA3D is one of the workhorse tools used by LLNL analysts for its ability to handle the nonlinear behaviors of structures/continuum, especially under fast transient loads.

Project Goals

This project undertakes the deployment of user-requested features, general technical support of users, and document update for DYNA3D. It also supports LLNL's collaborators program and the distribution of software to DOE's Energy Science and Technology Software Center. Together, these activities are needed to retain DYNA3D as a major simulation capability.

Relevance to LLNL Mission

New functionalities, maintenance, and technical support are essential to analysts contributing to ongoing projects in many LLNL programs. Many of these projects involve the Laboratory's collaboration with other institutions and federal agencies, such as Los Alamos National Laboratory, the Department of Homeland Security, and the Bureau of Reclamation. DYNA3D is a premier capability for simulating nonlinear, transient response of solids and structures.

FY2004 Accomplishments and Results

In computational structural analysis, a user-specified displacement history over portions(s) of the structure is a common way of imposing external loading functions. This is especially true in simulating a test procedure or during a verification/validation study. Due to DYNA3D's velocity-based formulation, such prescribed displacements must be converted to velocities for proper incorporation. The conventional assumption of linear variation between given displacement data leads to step-like, piecewise-constant velocity histories. Such velocity discontinuities can in turn cause excessive artificial high-frequency responses, commonly known as *noise*, in the analysis results.

The new algorithm uses the central difference operator to obtain discrete velocity

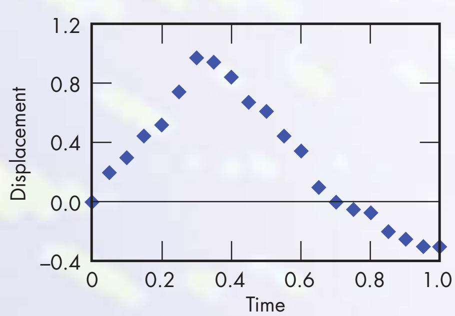

Figure 1. Sample of user-prescribed displacement input.

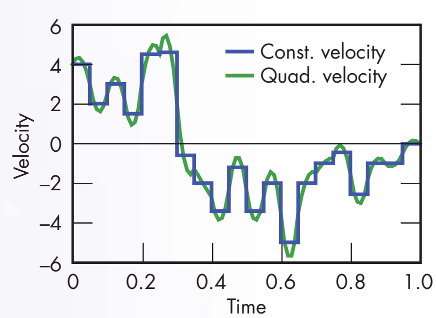

Figure 2. Velocity histories derived from the prescribed displacements by different interpolations. The feature implemented provides the smooth, quadratic velocities.

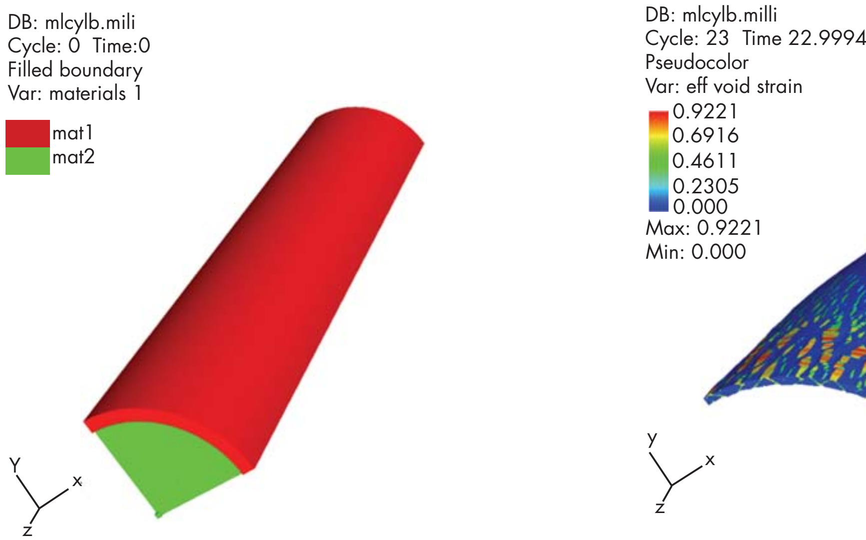

Figure 3. A cylindrical metal tube (red) with detonated HE (green). The detonation wave moves in the negative z direction. The figure shows the development of shear bands (localized regions of large deformation) and fractures. This simulation used the 3-D anisotropic fracture model MARFRAC, which was coupled to a Steinberg-Guinan plasticity model.

data for times of a given displacement. These generated velocity data, along with the user-specified displacements, afford a higher-order interpolation of velocity histories. The interpolated velocity history is continuous and piecewise-quadratic in time. It also yields the exact displacements at the user-specified points. Figure 1 shows a sample of user-specified displacement history. The comparison between corresponding piecewise-constant and piecewise-quadratic velocities is shown in Fig. 2.

Two material models were modified to improve their performance or capability. The elastic-plastic material with oriented cracks was modified to avoid undesirable residual tensile stress and spurious surface loads. A 3-D anisotropic fracture model (MARFRAC) was coupled to the Steinberg-Guinan plasticity model. The model was tested and incorporated into the main DYNA3D software. An example calculation using the new model, the HE-driven expansion and fracturing of a metal cylinder, is shown in Fig. 3. This finite-element mesh contains approximately 10 million elements and was run with ParaDyn, a parallel processing code based on DYNA3D.

Adoption of the Mili I/O library has lent unprecedented flexibility to DYNA3D's visualization output. Many results and parameters that could not be included in the old output format have become available for inclusion in the Mili output database. Because of the large variety of available state variables and parameters, we elect to add them according to user requests. In FY2004, we also added nodal reaction forces and current volume/pressure for closed volumes in the DYNA3D output database.

FY2005 Proposed Work

Due to the varying demands of user support and user-requested feature addition, our typical planning strategy is to identify a set of logical "next steps" for feature deployment. For next year these features include:

1. Adding surface-related quantities to the visualization output database upon full deployment of the surface class capability in the Griz visualizer. This new class will enable many additional state variables and parameters to be included in the output database.
2. A more consistent and robust algorithm for stiffness-proportional damping to replace the existing approach. Its effect on the system stability limit will be fully considered in the time-step calculation.
3. Continuation of coding of revised algorithms for contact detection and interference resolution. This work focuses on the interaction between segment pairs, instead of the existing node and segment approach.